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The Physiography of California

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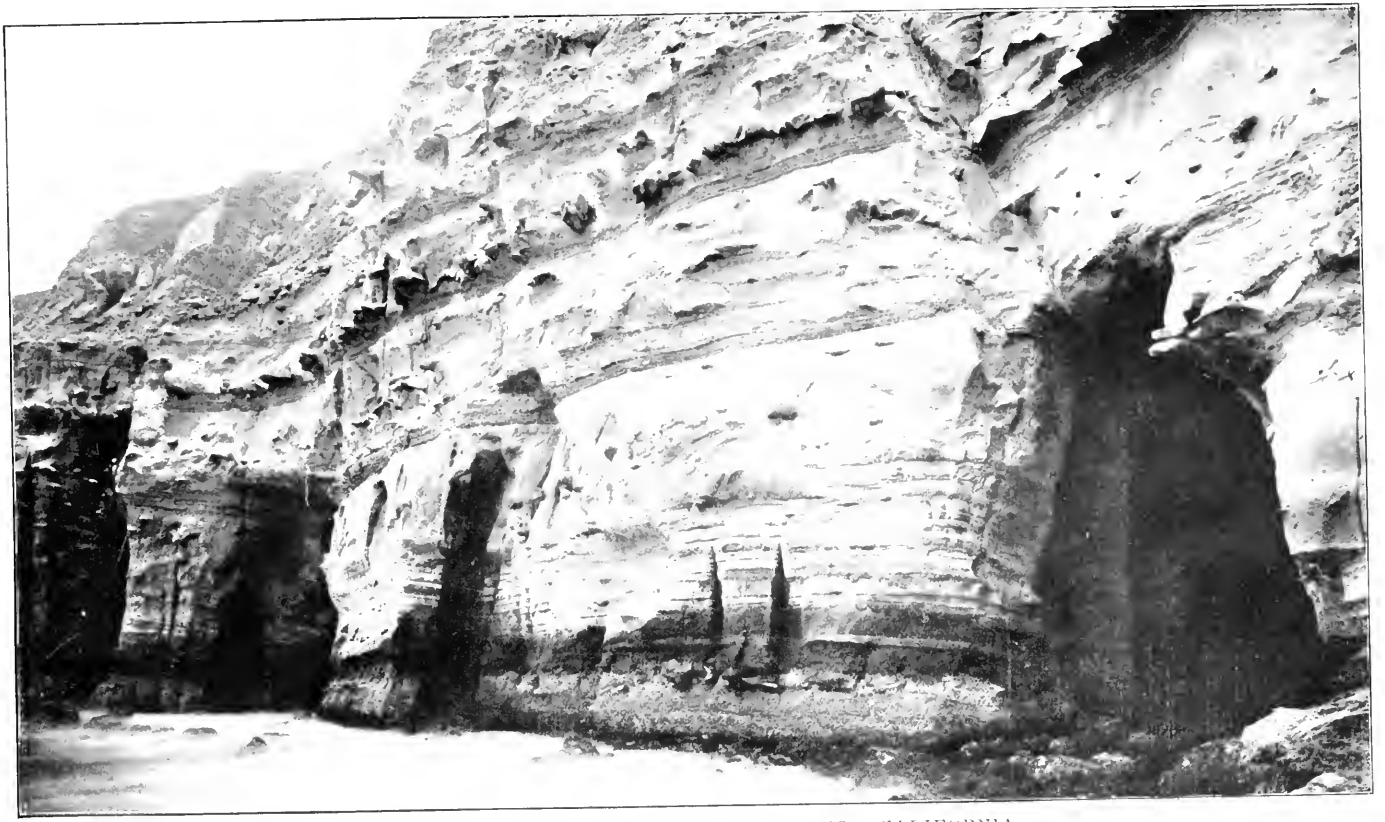


CAVES AT LA JOLLA PARK, NEAR SAN DIEGO, CALIFORNIA.

"The face of the cliff for a distance of several miles has been sculptured by the waves into most curious forms."

THE PHYSIOGRAPHY OF CALIFORNIA

BY HAROLD W. FAIRBANKS, PH. D.

That portion of the Pacific Coast region embraced within the state of California is characterized by a remarkable diversity in its topographic features. The relative position of the mountain ranges, valleys, and plains, and the direction of the prevailing winds have given rise to great contrasts in climatic conditions as well as a variety of productions. Regions of excessive heat contrast with those of perpetual snow; regions of humidity with those of aridity; while broad valleys devoted to fruit and grain adjoin mountains filled with the precious metals.

For the full understanding of the physiography of a region, the student must know something of its geological history. How especially true this is of California will appear in the course of this paper.

Physiographically, California cannot be treated as a whole. It is divided often by sharp lines into strongly contrasting provinces which have been subjected to different conditions, and exhibit different types and phases of physiographic development. In one portion volcanic features, often but slightly modified by erosion, predominate; in another those characteristic of recently uplifted mountain blocks; in another forms of mature or far advanced topography; and in still another those resulting from coastal elevation or submergence.

No other state in the Union contains more interesting material for the study of physiography, and for observing the bearing of this upon human life, than does California. Geography should here attain a full and symmetrical development.

GENERAL PHYSIOGRAPHIC FEATURES OF THE PACIFIC SLOPE

The important features of relief of the Pacific coast region have a general north and south direction varying in places near the coast to northwest and southeast. These are a result of structural conditions.

We may distinguish in a broad way four physiographic divisions as we pass from the Rocky Mountains westward to the Pacific ocean.

(1) The Great Basin and Plateau region. Nevada and the eastern portion of California lie in the Great Basin, while eastern Oregon and Washington is occupied by a vast elevated tract continuous with the Great Basin and known as the Columbian plateau.

(2) These areas are bordered upon the west by an almost continuous mountain block of great magnitude, embracing many of the highest peaks in the United States. In California where this range reaches its greatest elevation it is known as the Sierra Nevada. In northern California, Oregon and Washington it is termed the Cascade Range.

(3) West of this line of mountains lie the most important valleys of the Pacific Slope. The largest of these embraces the San Joaquin and Sacramento valleys, known altogether as The Great Valley of California. This valley extends in a direction a little west of north thru the heart of the state. Similarly situated in Oregon is the Willamette valley; and in Washington, the large valley partly submerged by the waters of Puget Sound.

(4) Separating this line of valleys from the Pacific ocean there is another series of mountains fully as continuous as the Sierra Nevada-Cascade block, tho less elevated, and designated in general terms as the Coast Ranges.

Different portions of the Coast Ranges are known under different names. In Washington there are the Olympic mountains; in northern California and Oregon the Klamath mountains; and thru California many other local terms which will be given later.

At the southern end of the Great Valley the Sierra Nevada mountains blend with the Coast Ranges in a complex group. Continuing easterly beyond this point the Coast Range axis is known in a broad way as the Sierra Madre mountains. South of San Bernardino the designation Peninsula Range is applied to those mountains which extend southerly into the peninsula of Lower California.

GEOLOGICAL HISTORY AS RELATED TO THE PRESENT TOPOGRAPHY

We trace the beginnings of the broader features of the present topography far back in Tertiary time. Altho the mountain axes of the California region were outlined at a much more remote

period yet those processes which developed the peneplain, the remnants of which are to be distinguished upon the mountain summits over much of the state, seem to have carried on their work thru the middle and late Tertiary.

The geography of the state near the close of the Miocene was very different from that of the present day. The ocean filled the Great Valley and spread over large portions of the Coast Ranges. The Lassen's peak volcanic ridge which now connects the Sierra Nevadas with the Cascade Range was not in existence at that time and the Sacramento valley was consequently open at the north. A series of more or less connected lakes of fresh water stretched at about ocean level across northeastern California into southern Oregon. Thru a protracted period of erosion, not without interruptions, the Sierra Nevada Range had been reduced to one of low relief. The streams flowed sluggishly in broad valleys, and the climate and vegetation were quite different from that of the present day.

The Klamath mountain region was probably an island at this time. It had also been worn down and a peneplain similar to that in the Sierra Nevadas extended over much of it.

Remnants of an ancient peneplain also appear upon the mountains of southern California. They exhibit about the same degree of degradation and are to the best of our present knowledge referable to the same period as those in northern California.

Toward the close of the Miocene period important mountain making movements affected the region of the Coast ranges. Protracted erosion followed the uplift. Then subsidence took place with the deposition of extensive beds whose position is on the border land between the Miocene and Pliocene. After the deposition of these beds uplift and folding again occurred. Then the Coast ranges appear to have been submerged again with the deposition of beds, both fresh water and marine of Pliocene age.

The movements of the central Coast ranges were undoubtedly felt in the Klamath mountains and in the Sierra Nevadas, but we have not there the criteria to distinguish them as certainly. There were intervals of renewed cañon cutting in these latter regions but the sum total of the results seems to have been a continuation of the base leveling.

A large part of the Pliocene was probably a period of depression in the whole Pacific coast region. The Coast ranges were

however not as completely submerged as in the Miocene, and there are reasons for believing that the oldest recognizable peneplain remnants date from this time.

Extending south from the Klamath mountains nearly to San Francisco bay there is an ancient plain truncating the mountains. During the Pliocene it received the finishing touches as did also that upon the Sierra Nevadas and in Southern California.

The north and south mountain blocks of the Great Basin region may have originated during Cretaceous time: but toward the close of the Tertiary renewed movements affected them. The Sierra Nevadas were raised by a tilting of the block until it reached a hight perhaps as great as the present. Similar fault movements must also have disturbed the Coast ranges, in places breaking up the Pliocene peneplain. Volcanic outbreaks were associated with the movements of late Tertiary time. At the northern end of the Sierra Nevadas the outpouring lava filled up the depressed basin and formed the Lassen's peak volcanic ridge. Farther north they built up the great Cascade platform.

Volcanic action at several distinct periods filled up the ancient river channels of the northern Sierra Nevadas forcing the streams to seek new ones. Volcanic action also occurred in portions of the Coast ranges upon an extensive scale and upon the coast islands. Thus we find that near the close of the Tertiary period the geographic features of the Pacific slope underwent a radical transformation.

Erosion actively took up the task of destroying the newly elevated mountain blocks. In the Sierra Nevadas, Klamath mountains, and in the Sierra Madre of southern California the great cañons of the present day were begun. Erosion went on actively also in the Coast ranges and the details of the present drainage were worked out, but here the larger valleys of the present day were already in existence. They originated in part during the folding at the close of the Pliocene, and in part earlier as a result of the combined influence of structure and erosion. The whole region under discussion must have attained an elevation greater than the present and maintained this elevation until the cañons had attained nearly their present proportions.

Concomitant with this elevation, and perhaps as a result of it, the Sierra Nevadas, Klamath mountains and Cascade range became glaciated. The scouring of the ice modified the mountain topography somewhat, especially the cañons, leaving as a heritage to the

present day the hundreds of basins in which lie the beautiful lakes so thickly scattered thru the high Sierras.

The Glacial period was followed by a general depression until the Coast ranges were submerged 1,000 to 1,500 feet below the level now existing. During the period of submergence partial peneplains were formed in different portions of the Coast ranges where the conditions were favorable. As the country began to rise the terraces which are so characteristic of the ocean front and of many of the river valleys came into existence. The movement continued until the coast was again several hundred feet higher than now. Finally came the last submergence drowning the mouths of the streams and giving rise to San Francisco bay.

These are, as far as they are known, the chief events which have left their impress upon the topography. From this brief outline it is not difficult to see that the topographic features of California are the result of many and diverse physical conditions. At the present time a discussion of the topography in all its phases can only be tentative. Much more investigation is necessary before we can be sure that we have a true story of even the recent geological events upon the Pacific coast.

TOPOGRAPHIC PROVINCES

For convenience of discussion the state will be divided into the following provinces: (1) The Sierra Nevada mountains, (2) The Great Basin region, (3) The Volcanic Plateau region, (4) The Great Valley of California, (5) The Coast ranges, (6) The Klamath mountains, (7) The Sierra Madre and Peninsula ranges, (8) Coastal features.

Some of the divisions here made are natural ones, others are assumed for convenience. For instance, the Klamath mountains, Coast ranges and Sierra Madre mountains constitute a continuous mountain axis the whole length of the state. The drainage features also are not defined by the boundaries of the different provinces. The Pitt river rises in the volcanic plateau region and crossing the axis of the Sierra Nevada-Cascade block joins the Sacramento in the Great Valley.

The Sierra Nevada Mountains. The Sierra Nevada mountains extend from about thirty-five degrees north latitude in a northerly direction, and finally a little northwesterly nearly to Lassen's peak in latitude forty degrees, thirty minutes; thus having a length of

about four hundred miles and a width averaging nearly eighty miles. The highest portion of the range, and that which forms its watershed, lies very close to its eastern edge. For fully two hundred miles thru the central portion of the range this divide is seldom lower than 11,000 feet and scores of peaks attain an elevation of nearly 14,000 feet, Mount Whitney reaching 14,522 feet.

The range rises very slowly from the Great Valley upon the west but breaks off with exceeding ruggedness upon the east. Except toward its northern end this mountain range is practically a unit so far as its history is concerned. The elevation to the present great hight has been brought about thru the formation of a fissure or series of fissures at its eastern base. Upon their western side the mountain ridges descend practically to sea level, but owing to the long gentle slope the elevation of the range cannot be appreciated from that side. It is only when seen from the valleys at the base of the fault scarp that the magnitude of the range can be appreciated. Altho these valleys vary from 2,500 to 6,000 feet in altitude, yet the wall of rock forming the scarp rises so abruptly and with such colossal proportions that it is almost overpowering in its grandeur.

Upon the south the range has often been considered as terminating at Tehachapai pass with an elevation of 3800 feet, the mountains continuing to the west of the pass and connecting with the Coast ranges, being known as the Tehachapai range. The distinction thus made is immaterial to the main fact that topographically the Sierra Nevada mountains bend around the southern end of the Great Valley and connect with the Coast ranges.

The mighty eastern fault scarp in all its distinctness may be considered as beginning in the vicinity of Walker's pass, a low portion of the divide east of Kern Valley. With a gentle curve the mountain wall sweeps toward the north rising higher and higher for one hundred miles until culminating northwest of Owen's lake in jagged peaks of the Mount Whitney region. From this point for another one hundred miles northerly there is but a slight lowering of the crest of the range, altho the displacement by faulting which at the lower end of Owen's valley is as much as 10,000 feet, decreases to not more than 5,000 or 6,000 feet in the Mono lake basin.

As we approach Lake Tahoe the single fault zone is replaced by two, the ruggedness of the range gradually decreasing as Mt.

Lassen is approached. Lake Tahoe lies in a depression due to the formation of two fault scarps and the dropping of the eastern block. South of Honey Lake valley the scarp of the eastern block presents a bold front to the northeast fully 3,000 feet high.

As we approach Mt. Lassen the older crystalline rocks of the Sierra Nevada mountains disappear under the comparatively modern lavas of the volcanic plateau of northeastern California.

Viewed from the summit of the Inyo range lying to the east of the highest portion of the Sierra Nevada fault scarp the evenness of the crest of the latter is most remarkable. The great peaks like Whitney are not isolated as are those of the Cascade range but lose their individuality in the mass effect. This uniform sky line which appears as we view the mountains from a distance, becomes, as we investigate them more closely, but a cover for a complexity of cañons and gorges of great depth and picturesqueness.

If we discard the deep cañons, the peneplain character, of the crest of the Sierra Nevadas, appears most strikingly from almost any point giving a good view over extensive areas. Many of the highest peaks including Mount Whitney have flat or gently sloping summits bordered by precipitous walls. As one ascends the long gently inclined ridges of the western slope he is constantly reminded of an ancient plain now elevated and undergoing degradation. The evenness of this plain is often enhanced by the comparatively uniform surface of the old river beds which cap the ridges between many of the cañons of the central and northern Sierras.

The streams of the old peneplain before the re-elevation of the mountains, were choked with waste and mingled in this waste was the gold from the broken down quartz veins. Toward their headwaters the topography was undoubtedly quite rugged in places, but by far the greater portion of the western slope, thru continued erosion and the choking of the streams, was destitute of any marked relief. The older gravels date from the Miocene or earlier times and the discordance between these and the more recent ones indicated periods of disturbance.

The volcanic outbreaks inaugurated in late Pliocene were continued thru a considerable interval of time. The lavas flowed from fissures along the crest of the range near lines of disturbance. They increased in amount toward the northern portion of the range where the eruptions of mud, ashes, and lava flowing down the valleys completely buried them. The most remarkable flow remaining

is that known as Table mountain. This is found in Tuolumne county and extends from the high mountains many miles down into the foothills. The country about it is now lower and many tunnels have been run under it to obtain the gold in the buried gravels.

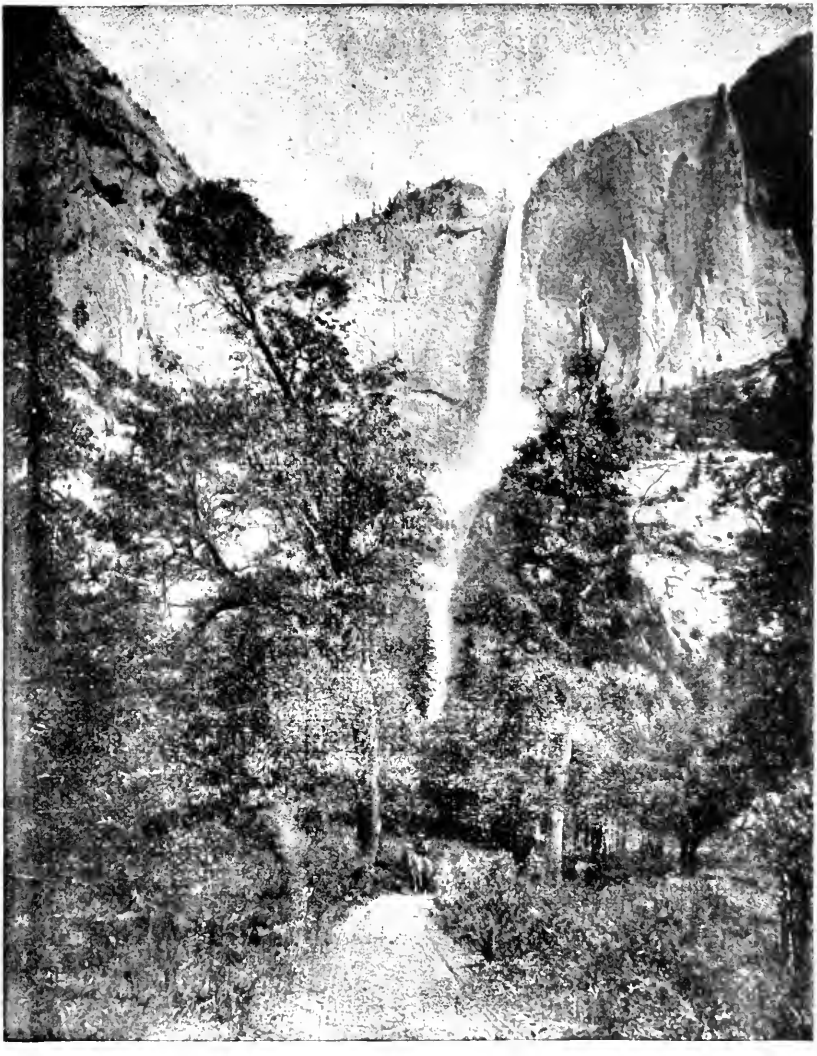
The volcanic material deposited in the river beds whether fragmental or massive appears to have been quite resistant to erosion and so in many cases permanently displaced the old streams. In the southern portion of the Sierras there was little or no volcanic capping and the old channels have been practically removed since the uplift of the mountains. It is probable also that thru the central Sierras the uplift was greater than farther north, so that erosion would be more vigorous.

In the region of the high Sierras rise those streams whose cañons have made the scenery of these mountains famous. The Tuolumne, Merced, San Joaquin, Kings, and Kern rivers have eroded cañons 3,000-5,000 feet deep. The most noted of these are the Yosemite valley, Hetch-Hetchy valley, and Kings river cañon.

The most of the streams which have cut the great cañons have not yet reached a graded condition unless it be near the borders of the mountains where they emerge upon the plains of the Great Valley. Their banks are generally steep and but little bottom land exists along them. Near the southern end of the Sierras, however, as well as at the north, there are valleys of considerable extent seemingly pointing towards a longer existence of the present conditions in those regions coupled with a lesser amount of uplift. At the south the Kern valley is a notable example, while the Sierra valley at the north is even larger in extent.

The drainage of the eastern slope of the Sierra Nevada mountains is short, but the streams descend with great velocity to the valleys of the interior basin. The larger ones are Owens, Walker, Carson, and Truckee rivers.

The formation of a double fault block from a point a little south of Lake Tahoe has given rise to the Tahoe-Sierra valley thru a partial dropping of the eastern block. The eastern face of the latter block gives rise to the bold mountains southwest of Honey Lake valley. In the Tahoe-Sierra valley, close under the fault scarp of the western block, lie Lakes Tahoe, Donner, Independence and Weber. These are all drained by the Truckee river which flows easterly and northerly across the dropped block, reaching finally to Pyramid lake in the Great Basin.



THE YOSEMITE FALLS.

Lake Tahoe is the largest of the bodies of water along the base of the fault scarp. It is one of the most beautiful lakes also of the whole Sierras. It owes its existence to a lava dam formed across the ancient valley of the upper Truckee river. This fault scarp extends north of the lakes bounding Sierra and Mohawk valleys upon the west, but gradually disappears. This has permitted

Feather river to extend its basin eastward so as to drain both the valleys mentioned westward into the Sacramento.

Waterfalls of great hight and beauty are frequently found where the smaller streams join the main rivers, as in the case of those in the Yosemite valley. The fairly uniform hardness of the rocks, chiefly granitic over large areas, has resulted more often in swift rapids than in waterfalls.

The gold bearing belt upon the western slope of the Sierra Nevada mountains is known world-wide. The Mother Lode, a series of gold bearing quartz veins extending for more than 100 miles thru the foothills, exhibits in places such large bodies of quartz as to have had considerable effect upon the topography. The system of fault plains running parallel to the range thru the mineral region has, in connection with dikes of igneous and metamorphic rocks of varying hardness, determined in great measure the courses of the smaller streams in the western or foothill belt. They exhibit a fairly complete adjustment to such conditions, but the main courses of all the larger streams are consequent upon the slope of the mountains.

From the relation of the glaciated surfaces to the present cañons it is believed that the latter were largely excavated before the Glacial period. It is probable that the ice during this time nowhere reached much below 4,000 feet in the Sierras, while toward their southern end 8,000 feet was the limit.

The higher portions of the mountains were swept bare of all loose and disintegrated material by the ice, and the harder rocks, generally granitic, were finely grooved and polished. Glacial moraines are particularly well shown upon the eastern slope where the ice streams passed out of the cañons on to the edge of the desert basins. Vast quantities of fragmental material thus encumber the mouths of many cañons and in some cases have given rise to beautiful lakes. The basins at the heads of the streams often exhibit very finely the characters of glacial cirques, being walled in upon their upper sides by nearly precipitous cliffs 1,000-2,000 feet high. The cañons descend by successive steps from these cirques at their head to a point near the foot of the fault scarp. Many of the basins are occupied by lakes which are either entirely rock rimmed or inclosed upon their lower edges by morainal walls.

The rolling, rock-ribbed surface of the high Sierras is fairly dotted with glacial lakes. These elevated regions with their bare and

polished rocks appear to have been glaciated so recently that it has been thought that the Glacial period was later here than in the eastern portion of the continent.

Various explanations have been given to account for the remarkable features of the Yosemite valley. This valley lies in the heart of the Sierras and is traversed by the Merced river which

EL CAPITAN, YOSEMITE VALLEY.

enters it by a series of rapids and waterfalls, and leaves by a narrow cañon. The valley floor, which is about three-fourths of a mile wide and eight miles long, has an elevation of 4,000 feet, while the mountains enclosing it rise 3,000-5,000 feet more. Some portions of the inclosing wall are practically vertical to hights varying from 3,000-4,000 feet. The Yosemite creek enters the valley in three falls measuring altogether 2,700 feet.

A study of the structure of the granitic rock of the region shows that it is traversed by systems of joint-planes. Where these are inclined the walls are sloping, but where the main system is vertical the agents of erosion, water and ice, have widened the cañon to a valley with steep or vertical walls. It is also probable that where the valley lies the rocks were exceptionally fissured and thus more readily disintegrated and eroded. This joint structure in the granite has controlled much of the detail in the scenery of the whole Sierra Nevada range.

Portions of the granite of the high Sierras, especially in the vicinity of the Yosemite and Kings river cañon, weathers out in great dome-like forms. This is undoubtedly produced thru concentric weathering in portions of the rock not so permeated with joint planes. The great south dome of the Yosemite is a typical example.

The same agents then which have produced the great cañons have given rise to the Yosemite, only here they have been aided by exceptional conditions in the rocks.

The Great Basin Region. In the early Cretaceous the Sierra Nevada and Great Basin ranges were not in existence. It is believed however that the region as a whole was considerably elevated but owing to earth strains was at last brought into a condition of unstable equilibrium. This resulted in the formation of north and south fissures and the whole region between the present Sierras and the Wasatch range broke up into a series of crust blocks. The crust blocks moved upon each other, some sinking, others rising. The depressed one gave rise to the valleys, the uplifted ones to the mountain ranges. Movements along these fault fissures have continued at times to be manifested down even to the recent period. As late as 1872 displacements as great as forty feet took place in Owen's valley and at other points thru western Nevada.

The disturbances which elevated the Sierra Nevada mountains at or near the close of the Pliocene probably also affected many other ranges of the Great Basin, for the fault scarps of many of them are fully as abrupt as that of the eastern face of the Sierras.

The valleys of the Great Basin are generally hot and arid. They range in elevation from that of Death valley, about sixty-nine feet below sea level to 6,000 feet above. The mountain ranges are high, many of them reaching an elevation of 10,000 feet. The Inyo and White mountain ranges attain an elevation in places nearly

equal to that of the Sierra Nevada, White mountain peak at the extreme northern end of the latter range towering to 14,000 feet.

That portion of the Great Basin within California exhibits two distinct phases of topographic development. (1) That lying east of the Sierra Nevada. This is typical of the Great Basin as a whole; that is, it is characterized by arid or semi-arid valleys inclosed between high and rugged north and south mountain ranges. (2) That in southeastern California lying between the Sierra Nevada and Sierra Madre ranges, and including the Colorado desert. The northern part is an elevated region known in general terms as the Mojave desert. It is characterized by a lack of recently faulted crustal blocks and has an irregular mountain structure. The mountains are low and nearly buried in their own waste, which has accumulated for a long time in the inclosed basins. This latter region is typical of an old topography and may with reason be considered as an illustration of how the Great Basin would appear as a whole if it had not been broken up by faulting.

In discussing the features of the Great Basin in detail, the portion exhibiting low relief will be taken up first. The basin of the Colorado desert is separated from the Mojave desert by a low range of mountains forming the southeastern continuation of the San Bernardino range. The Colorado desert is in simple terms the northern portion of the depressed area occupied by the Gulf of California. It has been gradually cut off from the gulf by the delta material brought down by the Colorado river. The lowest portion at Salton lies 260 feet below the level of the sea. A portion of the Colorado river during stages of high water is frequently diverted thru a channel known as New river. This latter river runs northerly and if the water is sufficient reaches the Salton basin, forming a broad and shallow lake. It cannot have been a very long period since the basin was occupied by a permanent sheet of water, for the old shore lines are very distinct. Extensive salt works are situated at Salton, the salt being scraped up from the deposit covering the surface of the basin.

The area of the Mojave desert is somewhat triangular in shape. It is between 200 and 300 miles wide from north to south along the eastern border of the state, but gradually narrows westward as the Sierra Nevadas and Sierra Madre approach each other, and terminates at their meeting point. The area is sharply marked off upon the south by the Sierra Madre mountains, but upon the north the

irregular ranges gradually give place to the north and south fault ranges. This region is hot and exceedingly arid except toward the western end, where a portion known as Antelope valley receives some rainfall.

Many lake basins dot the surface of the Mojave desert. During the Glacial period these were filled with shallow bodies of water, but now they are dry and expose vast stretches of yellow clay. The only stream which penetrates the desert is the Mojave river. It rises upon the northern slope of the San Bernardino range and finally sinks in the center of the desert.

The most impressive feature of this region is that of the long waste slopes which center about the scattered mountain peaks and slope away for miles in every direction, terminating upon the borders of the ancient lake beds. Over wide stretches the mountains have nearly disappeared beneath these waste slopes, rising only as small rocky knobs browned under the influence of the intense heat of summer. Toward the eastern edge of the area there are higher mountains, but the waste slopes are fully as prominent. Pilot knob reaches a hight of 5,500 feet, but the most of the valleys vary between 1,800 and 2,500 feet.

The topography illustrates most excellently the conditions which finally arise in the course of the degradation of a mountainous region from which the waste cannot be removed because of the lack of an outlet. It also illustrates the effects produced by erosion in an arid climate. What little rain there is comes in sudden and severe storms at rare intervals. The rush of water sweeps the debris from the mountain cañons out upon the valleys at their mouths. There the waters no longer confined spread out and drop their load in the form of debris fans or cones. These coalescing when the cañons are near together give rise to the long and gentle slopes.

The immense quantities of fragmental and rudely stratified material forming the even slopes clustered about the peaks, and leading down to the inclosed basins or sinks, impresses one with the power of the destructive agents. Everywhere the desert seems a region of waste and desolation.

Recent volcanic action has occurred at a number of points. Finely shaped lapilli cones, and long winding flows of black basaltic lava free from soil and unmodified by erosion, are characteristic forms.

The lake basins upon the northern edge of the area were supplied during the Glacial period with water from the melting snows upon the Sierra Nevada mountains. The great Borax marsh, whose surface is now whitened almost as far as the eye can reach by the efflorescence of different salts from the moist clays beneath, was then occupied by one of these lakes. The marsh is partly inclosed by mountains upon whose slopes are still well defined beach lines of the ancient lake.

We pass by degrees from the structureless region of old topographic forms to that upon the north, where the north and south fault lines give place to rugged and often youthful forms. At the southern portion of the latter region are the Panamint, Amaragosa, Coso, and Slate ranges. The highest of these is the Panamint, which at one point reaches an elevation of 10,000 feet. These mountains do not occur as isolated blocks, but sending off spurs interlace so as to give rise to valleys more or less separated from each other. The mountains rise to a hight sufficient to give them a light rain or snowfall and are covered, about their summits, with a scanty growth of nut pine. There is scarcely any precipitation in the valleys but occasional springs occur near the edges of the valleys. They are undoubtedly connected with the fault fissures. Death valley is the most widely known of all these depressions. It has a length of about fifty miles and a width of ten. The center of the valley lies below the level of the sea. The great stretches of alkali flats in this valley acquire an intense heat during the summer days, and have proved disastrous to many a prospector.

Panamint valley, upon the opposite side of Panamint range from Death valley, is nearly as large, but has an elevation of 1,300 feet. Farther west and across the Argus range is Salt Wells desert, reaching up to the base of the Sierra Nevada mountains. The waste slopes in some of these valleys have spread out so far as to nearly or quite obliterate the alkali beds of the former lakes.

Toward the southern end of the area under discussion the mountain slopes are more dissected and do not show such marked indications of recent movement. To the north, however, lies the Inyo-White mountain range, having a length of nearly 100 miles. Thruout much of its length, especially upon its eastern side, this mountain block presents a fault scarp nearly as high and fully as precipitous as that of the Sierra Nevada mountains. Upon the western border of Saline valley, which lies at the eastern base of

the Inyo range, the latter appears to have undergone marked elevation in very recent times. The borax marsh in the bed of the valley lies close under the bold eastern front of the range. The displacement here must be between 8,000 and 10,000 feet.

Owens valley is one of the most interesting basins of eastern California. It occupies the enormous sunken area lying between the Sierra Nevada range and the Inyo-White mountain range. At the southern end of the valley is Owens lake, one of the largest of the remaining basin lakes of California. It has an elevation of 3,700 feet and lies close under the fault scarp of the Sierra Nevada range. The depressed crustal block, or rather blocks, forming the valley extend northerly from the lake for about 80 miles with a width of 10 miles. Owens river traverses the valley, rising in the Sierras opposite its northern end and emptying into the lake. Many small streams enter the valley from the west and are used for irrigation. How completely the Sierras cut off the moist winds is shown by the fact that altho the Inyo and White mountain ranges in places rise nearly as high, yet the precipitation upon them is very light.

During the high water stage of the Glacial period Owens lake overflowed its basin. The waters poured thru the long depression extending southerly from the lake and close under the Sierras, and passing the narrow gap where the Coso mountains come so close to the Sierras, emptied into Salt Wells desert. From the latter region they spread to the borax marsh already described. The ancient bed of this now dry river corresponds in hight to the uppermost terrace of Owens lake. The river was fully 1,000 feet wide and its ancient channel is now followed for thirty miles by the wagon road from Mojave to Owens valley.

Running thru the middle of the Owens valley depression and toward its southern end there is a line of hills called the Alabama hills. These have an abrupt front to the east rising 200-300 feet above the sandy river bottom. This shows that the valley is divided into at least two longitudinal blocks, the eastern one having been dropped more than the other. As a feature of the earthquake of 1872 a new fault line was formed in the valley near this scarp, the valley dropping 10-40 feet more.

Volcanic flows and cinder cones mark the line of displacement in Owens valley at several points. North of the town of Bishop at the upper end of the valley a broad table land of volcanic ash

commences and extends many miles in the direction of Mono lake. The table land gradually rises to a low divide and is then replaced by low ridges of rhyolitic lavas, between which are extensive plain-like valleys covered with loose volcanic ashes.

Owens river has cut a cañon thru this plateau fully 1,000 feet deep. Along the summit of the valley, between Owens valley and Mono lake, the lavas have been piled up so as to nearly obliterate the fault scarp. As we approach Mono lake it again comes out very boldly, and at the lake the fault scarp, tho much eroded, is about 5,000 feet high. The settling of the basin in which Mono lake lies has forced the water close up under the scarp. Here also a recent movement has occurred, as shown at the mouth of Mill cañon by a wall of earth 40 feet high.

The region about Mono lake has been the theater of many volcanic outbreaks and earthquake disturbances. The islands in the lake are fissured and shattered, while upon the north shore of the lake at Black point there are open earthquake fissures.

Extending south of the lake for a distance of 10 miles there is a group of remarkable volcanoes known as the Mono craters. These have been formed thru the piling up of viscid lavas and vast quantities of pumiceous ash. There are craters here formed by explosions merely, by the piling up of ashes about an orifice, and by the upwelling of viscid lavas. Several of the craters from which pumice was at first blown were afterward the scene of outpouring lava. In two or more instances the lava cooled before overflowing the older crater of ash. These features have been unaffected by erosion and remain almost as perfect as when formed, making the region one of exceptional interest.

The waters of Mono lake, like those of Owens lake, are intensely alkaline. Judging from the terraces, the lake did not overflow its basin during the Glacial period.

For some distance north of Mono lake the fault scarp of the Sierras is less bold and the region is largely covered with andesitic lavas. In these lavas occur the noted gold-sliver deposits of Bodie. Continuing toward Lake Tahoe we cross the valleys of the Walker and Carson rivers, which near the mountains are well watered and highly cultivated. After traversing a number of valleys the Walker river empties into Walker lake and the Carson spreads out in a sandy waste known as the Sink of the Carson in west central

Nevada. The Carson valley just over the line in Nevada is one of the largest and most fertile of the farming regions of Nevada.

Lake Tahoe has already been described in connection with the Sierra Nevada mountains, altho its drainage thru the Truckee river is into the Great Basin. This lake, with an elevation of 6,225 feet, but 200 more than Mono lake, is a sheet of pure cold water, contrasting strongly with the latter.

During the Glacial period a great lake called Lahontan spread over the now desert basins of northwestern Nevada and into the edge of California. A large remnant of this lake remains to the present day at the foot of the fault scarp in northeastern California. This body of water is known as Honey lake and has an elevation of about 4,000 feet. At present it has no outlet and is of course alkaline.

The Volcanic Plateau Region. The northeastern part of California is an extensive plateau region broken by numerous ranges of mountains. Under the above head will be discussed all that area lying east of a line connecting Shasta valley with the northern end of the Sierra Nevada mountains. The Lassens peak ridge and the line of extinct volcanoes reaching north to Mount Shasta and connecting with the Cascade range of Oregon have been included by some, and perhaps justly, in the Cascade range. The volcanic peaks undoubtedly do form a continuation of those of the Cascade range in Oregon, but thru northern California this range, aside from the scattered peaks, can scarcely be distinguished from the volcanic plateau region to the east. It is, in fact, continuous with that plateau.

The plains and valleys of this region have an elevation of 3,300 to 5,000 feet, while some of the mountains, exclusive of the volcanic peaks, attain a hight of 10,000 feet. The region is made up almost wholly of volcanic rocks, and is structurally as well as historically closely related to the northern portion of the Great Basin and the plateau region of eastern Oregon.

The greater portion of the area is fairly well watered, for the mountains on the west are not high enough to cut off the moist winds from the Pacific. Irrigation is, however, often resorted to, and in the extreme northeastern part the long fertile valley known as Surprise valley is largely dependent upon irrigation.

Numerous lakes, some of them of large size, are scattered over this region. They are remnants of much larger ones of the early

part of the Pleistocene period. Upon the borders of the area are several lakes without outlet, which might properly be included in the area of the Great Basin. These are Tule lake upon the borders of Oregon, and the Surprise valley lakes.

The major portion of the area is drained by Pitt river, the most important tributary of the upper Sacramento. Many of the valleys which Pitt river traverses, such as Fall River, were once occupied by lakes. The lakes were finally drained, partly perhaps as a result of mountain movements, and partly thru stream action. Pitt river in its upper course passes alternately thru broad plain-like valleys and deep cañons. The lake of Fall River valley had apparently no very high barrier upon the west. The lowest portion of this barrier is now traversed by Pitt river in a gorge of considerable depth and ruggedness. The extreme source of this river has been Goose lake, a large body of water lying partly in Oregon, but at the present time the waters of the lake seldom rise sufficiently to cause an overflow.

The Surprise valley lakes are shallow, and during some seasons almost wholly dry up. Eagle lake, in the southern portion of the area, has no surface outlet, but there must be one underground, for the water is perfectly pure.

Tule or Rhett lake is interesting in many respects. It together with the Klamath lakes formed one large body of water until Klamath river cut its present cañon and partly drained the old basin. Tule lake now has no surface outlet, but the waters are fairly fresh. Klamath river during stages of high water has until recently been partly diverted to Rhett lake, but this no longer happens. The region about the lake is quite arid and few streams enter it.

Interesting drainage features are associated with the recent extensive flows of lava. In such areas there is generally little surface water, but underground streams are frequent. Rugged lava fields stretch from Tule lake south into the upper end of Fall River valley. Much of this lava at least was formed since the lake period and altho vegetation has gained a foothold upon its surface, yet the rocks are quite free from soil and exceedingly rough. The surface of the flow contrasts strongly with the deep soil and heavy forests about it. Fall river bursts out in numerous large springs from beneath the end of the lava flow, and after winding sluggishly thru the valley for 15 miles enters Pitt river thru a series of swift rapids. The river has a very small local drainage and never varies

in size between winter and summer. Hat creek is a similar stream, which enters Pitt river from the direction of Lassens peak.

The mountains rising from this plateau region are mostly due to one of two causes, either the piling up of eruptive material or faulting. The physiographic history has certainly been a complicated one. The older mountains of the region exhibit no regular arrangement and have been much modified by erosion. The Warner mountains bounding Surprise valley upon the west constitute the best example of the Great Basin type of elevations in northeastern California. They extend north and south for about 70 miles, rising to about 10,000 feet elevation in the highest portion. They present a bold scarp to the east and a long gentle slope upon the west. This fault scarp has been deeply sculptured by erosion, and owing to the tuffaceous character of a portion of the lavas of which it is composed, often presents picturesque castellated forms.

Recent fault movements appear to have taken place along the base of the Warner range. The features produced by similar movements are to be found over many other portions of this plateau region. These consist of long lines of bluffs extending northerly and southerly with scarps 100 to 200 feet high. These perhaps more frequently face the west and traverse all but the most recent of the lavas.

The volcanic rocks of the greater portion of this plateau region have undoubtedly issued in a molten condition from fissures in the crust and not from definite centers like those which result in volcanic peaks. The line of great volcanic peaks stretching from the northern end of the Sierra Nevada range northward into Oregon grew up toward the close of the long period of igneous action, probably in the later Pliocene. They undoubtedly vary in age and have time and again been modified by new eruptions. Some are greatly dissected by erosion while others are comparatively intact.

Under the greater peaks we will include Mt. Lassen, Crater peak, Magee peak, Burney butte and Mt. Shasta. Lassen peak rises to a hight of 10,437 feet and is the center of an exceedingly interesting volcanic region. Cinder cone, a little to the northeast, was the scene of what was probably the most violent volcanic eruption in California. Judging from the tree trunks still standing in a field of volcanic ashes, this eruption could not have been more than two hundred years ago.

Burney butte is the most perfect of the larger volcanic peaks. It rises to a hight of 7,880 feet.

Mount Shasta reaches an elevation of 14,350 feet being next to Rainier, the loftiest peak of the Cascade range. Tho but a little lower than Mt. Whitney it presents a far more imposing appearance owing to the low mountains and open valleys which surround it. Strawberry valley at its southwestern base has an elevation of 3,550 feet and from this valley as well as from others upon the west and south the mountain presents an appearance so striking and grand that when once seen it can never be forgotten. Its summit, snow covered thru the year, with the dark forest encircling it below, is ever a feature of fascinating interest. Since the glacial period, lavas have issued from its sides, and one stream flowed for more than fifty miles down the cañon of the Sacramento river. Small glaciers still remain in sheltered depressions. The melting snows furnish water for a number of underground streams which break out in the cañons of the Sacramento and McCloud.

To the west of Shasta there rises a very perfect cone known as Sugar Loaf or Black butte. It towers over 2,000 feet above the valley.

In addition to the great volcanoes already described there are hundreds of smaller ones scattered over this region. The large volcanoes have been built up thru a combination of massive flows and fragmental material blown out. The smaller ones are almost all lapilli cones and generally do not rise more than 100 to 500 feet. They have steep slopes and crater-like depressions in their tops. They represent the last expiring forces of the volcanic period.

THE GREAT VALLEY

The Great Valley of California lies in the very heart of the state and is entirely enclosed by mountains save at the narrow outlet thru which its drainage passes. The valley is practically a vast plain about four hundred miles long and fifty miles wide. The San Joaquin river with its tributaries drains the southern arm and the Sacramento, the northern. These streams unite a little north of the central portion of the valley in a region of lowlands and marshes and pour their united volume thru the straits of Karquines into San Francisco bay. The two arms of the Great Valley rise very gently towards their extremities where they attain an elevation of not much over five hundred feet. Much of the lower portion of

the valley lying west of a line connecting Sacramento and Stockton is flooded during the spring rise in the streams. As a result of the recent coastal submergence much of this marshy land is subject to tidal influence, the tides being felt many miles up the sluggish streams. About Martinez the flat bottomed alluvial valleys with the abruptly rising hills also support the view of a subsidence of the region about the outlet of the Great Valley.

Owing to the light grade and the large amount of material offered for transportation, some of the streams flow upon channels elevated above the surrounding country. For many miles the Sacramento river is bordered by narrow banks of dry land behind which are large stretches of marsh and overflow land.

The moist winds from the ocean pass inland across the Coast Ranges, so that the eastern slopes of the latter receive much less rain than the western. The Sierra Nevada mountains being higher than the Coast Ranges, their western slope is well watered while the streams are maintained thru the summer by the melting snows. As a result of these conditions only few permanent streams enter the Great Valley from the west, and these are confined to the northern portion known as the Sacramento valley. The southwestern portion of the San Joaquin receives a very scanty rainfall.

The Great Valley occupies a structural depression of considerable geological age. The greater portion has either been near the sea level or beneath it for long periods of time while the surrounding mountains, particularly the Coast Ranges have undergone folding and faulting.

The surface of the valley is in part formed of delta deposits, of the present streams, of recent lake beds, and of the slightly eroded surface of uplifted beds of Pliocene age. The floor of the valley blends imperceptibly in many places thru the foothills into the ancient peneplain of the Sierra Nevada mountains. Upon the Coast Range side the mountains rise more abruptly, and in the San Joaquin valley in particular there are long waste slopes built up by the action of the wet weather streams.

Along the eastern edge of the central portion of the Great Valley the streams are large and have cut down slightly into the stratified sedimentary deposits of an earlier depression. Waste slopes and delta deposits are not prominent. Farther south however we find that the Kings and Kern rivers have formed large deltas which have considerably modified the surface of the valley.

An examination of a relief map of California will show that the San Joaquin river lies much nearer the coast ranges than it does the Sierras. The greater watershed upon the east as well as volume of water and the large amount of waste brought from that direction have forced the river to the western side of the valley. The delta of Kings river has been extended across the valley so as to form an inclosed basin of the southern portion, from which there is overflow only in seasons of exceptional rainfall. This gave rise to Tulare lake, a large body of shallow water. With the increase of land cultivation and use of water in irrigation the lake is gradually disappearing. Kern and Buena Vista lakes are smaller bodies of water lying to the south. They are fed by Kern river chiefly and are dry during some seasons. The delta of the Kern river is dotted with cottonwood trees for miles, and altho formed of sandy material is very productive under irrigation.

The San Joaquin valley is, as a rule, destitute of trees except for fringes along the streams, but large portions of the Sacramento, receiving a greater rainfall are dotted with oaks. The accumulation of material in the Great Valley in recent times is enormous. Well borings in the center of the valley show that it is filled to a depth of more than two thousand feet with gravel and clay of lake or fluvatile origin. Remains of trees and land animals of Pleistocene age have been found in these deposits. The valley has either been the scene of delta accumulation above water as at present, or its surface has been occupied by a body of fresh or salt water. It is quite probable that at one time in its geological history the outlet was to the south instead of west as at present.

We find the old peneplain already referred to, particularly well developed upon the borders of the upper Sacramento valley. This plain is not now continuous with that extended over much of the Klamath mountains probably because of deformation which has occurred since. The streams which enter the Sacramento from the Klamath mountains have cut cañons thru the plain, but it is nevertheless a striking feature of the landscape.

The Feather river, one of the largest tributaries of the Sacramento, has, since hydraulic mining has been carried on, built up its bed to such a degree that it is now higher than the streets of Marysville and has to be restrained by levees.

The only marked elevation in the whole of the region under discussion is found in the center of the Sacramento valley west of

Marysville. It is known as the Marysville buttes. Here is a group of serrated and picturesque peaks rising about two thousand feet above the level and monotonous valley. They are known as the Marysville buttes and represent a deeply dissected volcano of late Tertiary time.

THE COAST RANGES

The presence of a continuous line of mountains along the coast of California has already been referred to. These mountains are known as the Coast Ranges or Coast Range system. As the name indicates, they are not made up of one dominant axis, but of several extending side by side and often having broad valleys between them. As we follow them northward toward the 40th parallel this

CAJON PASS IN THE SAN BERNARDINO RANGE.

composite character disappears. The broad valleys give place to cañons, and the regular mountain ranges to a broad group of rugged and irregular mountains. This latter region, lying partly in California and partly in Oregon forms the Klamath mountains. No definite limit has been established for the boundary of the Coast Ranges upon the north, and no natural one can be, unless it is upon geological grounds, for the Coast Ranges blend gradually into the higher and more rugged regions of the Klamath mountains.

Upon the south the Coast Ranges may be considered as terminating at the point where they meet the Sierra Nevada and Sierra Madre ranges. Here are the San Emedio mountains the highest point of which, Mount Pinos, reaches an elevation of over nine thousand feet. In this region also the limit placed upon the application of the term Coast Ranges is merely one of convenience. The

Sierra Madre together with the Peninsula range of southern California lie farther back from the coast, and the Sierra Madre in particular is separated from it by a complex structure of lesser mountains.

Thruout the most of their length the Coast Ranges have a very regular northwest and southeast direction being nearly parallel with the coast. The slight discrepancy in direction between shore line and mountain range has given rise to the most important of the shore-line irregularities. Where a mountain range comes out to the ocean there is a more or less prominent cape, while between that and the next range there is an indentation of the coast.

Toward the southern end the Coast Ranges change their course and extend more nearly east and west. Point Arguello is the seaward termination of the Santa Ynez range and marks a change in the direction of the coast line corresponding with the east and west structure of these mountains.

The geological structure of the Coast Ranges is exceedingly complex. Repeated folding and faulting thru a long period of geological time have followed a general northwest and southeast direction. The structural conditions together with great variations in resistance to erosion of different rock formations, and the frequent movements of the land as a whole with reference to the ocean level, have given us the complicated topography of the present day.

The drainage of the great interior region of the state passes directly across the Coast Ranges thru the straits of Karquines, San Pablo and San Francisco bays to the ocean. This gap in the Coast Ranges with its tributary valleys does not appear to be of structural origin but to represent what was a depression or sag in the Coast Ranges subsequently enlarged by the concentration of the drainage lines.

Thru the central Coast Ranges we cannot trace the same ancient peneplain, which we find in the northern Coast Ranges, the Klamath and Sierra Nevada mountains, unless it be in mere fragments here and there. The important structural features of the Coast Ranges date far back, but differential movement in recent geological times has been so marked as to mask or destroy topographic features which in more stable regions would have been preserved. Some of the mountain axes we know were not in exist-

once even as late as the Pliocene period. The Berkeley hills now rising nearly two thousand feet have upon their summits folded sediments of a fresh water lake of late Pliocene age.

In the latitude of San Francisco bay the Coast Ranges appear as three well defined mountain axes. Upon the east there is the Mount Diablo range and its topographic continuation across Suisun bay in the mountains east of Napa valley. In the middle there is the northern prolongation of the Mount Hamilton range corresponding on the opposite side of the bay to the mountain ridge between Napa and Sonoma valleys. Upon the west there is the Santa Cruz range south of the Golden Gate and the range of which Mount Tamalpais is the culminating peak. The valley between these ranges opening out to San Pablo and San Francisco bays are among the most fertile and highly cultivated in the state. The Santa Clara valley penetrated by the southern arm of San Francisco bay, and the Sonoma valley extending northwest from San Pablo bay are the largest; Napa valley comes next in size. Sonoma valley, and Santa Clara with its southeast prolongation, the San Benito valley, are each nearly one hundred miles long and attain a width in places of eight to twelve miles. Their nearly level bottom lands are formed of sediments deposited in long, narrow estuaries of the ocean during the last great submergence of the coast. All about the bay are low lands sloping gently back to the surrounding hills. These are of the same nature as the valley floors except for some modification thru stream action. The bay is shoaling in many places, and since the last submergence giving rise to the present sheet of water thousands of acres have been filled in with stream or delta deposits.

The hills come down quite boldly to the straits of Karquines, a fact which would be explained by the theory of a differential movement of the mountains with reference to the floor of the Great valley.

The broad valleys of the San Francisco bay region cannot be considered other than structural in their origin, but modified and enlarged by erosion. All cannot have had the same history. The sharp contrasts between the cañons which open back into the enclosing mountains and the broad, even-floored valleys would in itself suggest that the one is new, the other old.

All the features of San Francisco bay impress one as those of a drowned area. As the land sank the sea came in thru the Golden Gate, flooding the lower portion of the great river. The character of the bays and islands, and especially the filled in valleys between Sausalito and San Rafael, illustrate particularly well this last phase of the physiographic history of this region.

A YOUNG CANYON IN THE SIERRAS.

Mount Diablo dominates the outlet of the Great valley. It rises to a height of 3,850 feet, and is by far the most prominent and striking feature of the Coast Ranges as one approaches them across the Great valley. The core of this mountain is made up of the older rocks of the Coast Ranges (Golden Gate formation.) Its prominence is due in part to orographic movements, and in part to the more rapid erosion of the surrounding beds.

The mountains enclosing Napa valley as well as a considerable portion of the Coast Ranges extending north to Clear lake, are of volcanic origin. The highest peak of this volcanic region lies northwest of Napa valley. It is known as St. Helena and attains an elevation of 4,300 feet.

As we go northwesterly from San Francisco bay, the valleys become narrower and the mountains higher. Near the coast there are heavy forests of redwood, but farther inland the mountains become less timbered while the valleys are dotted with oaks.

About one hundred miles north of San Francisco and within the heart of the Coast Ranges, lies Clear lake. It is an irregular lake with a length of about twenty-five miles and an elevation of 1,310 feet. It is the only lake of any size within the Coast Ranges. The surrounding region was the scene of protracted volcanic action during the Pliocene period. Uncle Sam, a bold and picturesque mountain of volcanic origin, overlooks the lake and rises to a height of 4,200 feet. Mineral springs of many kinds abound in this section, and at the Sulphur Bank near the eastern end of the

lake, there is a most interesting example of solfataric action with deposits of sulphur and cinnabar.

The waters of Clear lake now empty thru Cache creek at its eastern end into the Sacramento river. The outlet of the lake was formerly westward thru the cañon-like depression, in which the picturesque Blue lakes lie, into a tributary of Russian river. Only a few feet rise of the waters of Clear lake, would, if the eastern outlet were stopped, again send the drainage of the lake westward directly to the ocean. The cause of the change of drainage has not been investigated. It may have been due to a tilting of the mountains or thru a lowering of the divide of Cache creek by erosion.

THE NEEDLES—Showing one type of Weathering.

North of Clear lake the Coast Ranges form practically a unit. There are but two slopes, a short one toward the east, and a long one westward to the Pacific. The crest gradually rises as we follow it northward, until in the Yallo Bally peaks it reaches a height of about 8,000 feet. The main stream draining the western slope in this section is Eel river. This stream and its tributaries exhibit a fairly well matured stage of development. The courses of the large streams are mostly subsequent, altho they still flow thru cañons, or valleys of no great width. Well formed terraces appear at many points along Eel river. At Humboldt bay, where this river comes out to the ocean, the higher mountains stand back some miles from the coast, and there intervenes a strip of level or slightly undulating country. A part of this land about

the bay is of delta formation, but the most has been eroded out of a soft Pliocene formation.

Russian river exhibits an interesting feature in its lower course. From a study of Sonoma valley, with its enclosing mountains, one would naturally expect to see Russian river, which drains it, passing southeasterly into San Pablo bay. The river does not do this, however, for a little above the city of Santa Rosa, it turns southwesterly and crosses the range between the valley and the ocean thru a winding cañon. The divide separating the Sonoma valley from the bay is very low, scarcely noticeable. It is probable that the stream has either been superimposed upon the range which it crosses, thru the removal of softer materials of the valley floor, or there has been an uplift of the mountain.

The structural and topographic features of the coast ranges south of San Francisco are more complicated than north. The extension of the Mount Diablo range to the southeast, forms the real crest, or backbone of the Coast Ranges. This divide lies very near the eastern edge of these mountains the whole distance between Mount Diablo and their southern termination in the San Emedio mountains. The divide varies much in height. East of Livermore, where it is crossed by the Southern Pacific, it is only eight hundred feet high, while near the middle of the range a height of nearly five thousand feet is shown in San Carlos peak.

The Mount Hamilton range which bounds the Santa Clara valley upon the east is not structurally distinct from the Mount Diablo range. The Lick observatory stands upon Mount Hamilton, the culminating peak, at an elevation of 4,210 feet.

The Santa Cruz mountains form a broad elevated block between the Santa Clara valley and the ocean. The highest peaks of the range rise to 3,500 feet or over. Following this range southeasterly we find it gradually decreasing in height until we reach the broad and low depression separating it from the Gavilan range which is structurally a continuation of the Santa Cruz range to the southeast. During the Pleistocene submergence, there was here as at San Francisco a broad channel permitting the entrance of the ocean into the large valleys within the Coast Ranges. A divide of but little over three hundred feet separates the Santa Clara valley from the San Benito valley, while the divide between the San Benito and the ocean, discarding the Pajaro cañon, has about the same height. The San Benito drainage may at one time have

gone down thru the Santa Clara valley into San Francisco bay. There are good reasons for thinking that the reverse was the case at one time, owing to the presence of a great submarine valley in the bay of Monterey and none opposite the Golden Gate. At present, however, the Pajaro river, draining the San Benito valley, has cut a narrow cañon thru the low pass separating the Santa Cruz range from the Gavilan and passes directly out to the ocean at Monterey bay.

The Gavilan range as a distinct mountain block has a length of about sixty miles when it blends with the Mount Diablo range. At its southern end are two prominent elevations known as the

NEAR THE SUMMIT OF MOUNT LOWE.

Chalone peak. The higher one is an ancient volcano of Tertiary age. The hardened tuffs to the north have weathered out in pinnacled forms of picturesque appearance.

The union of the Pajaro and Salinas valleys forms the extensive lowlands about the bay of Monterey. These were formed in great part during the last deep submergence of the coast. The Salinas river, with its important tributary, the Estrella, occupies the longest and most direct valley of the Coast Ranges. Near the

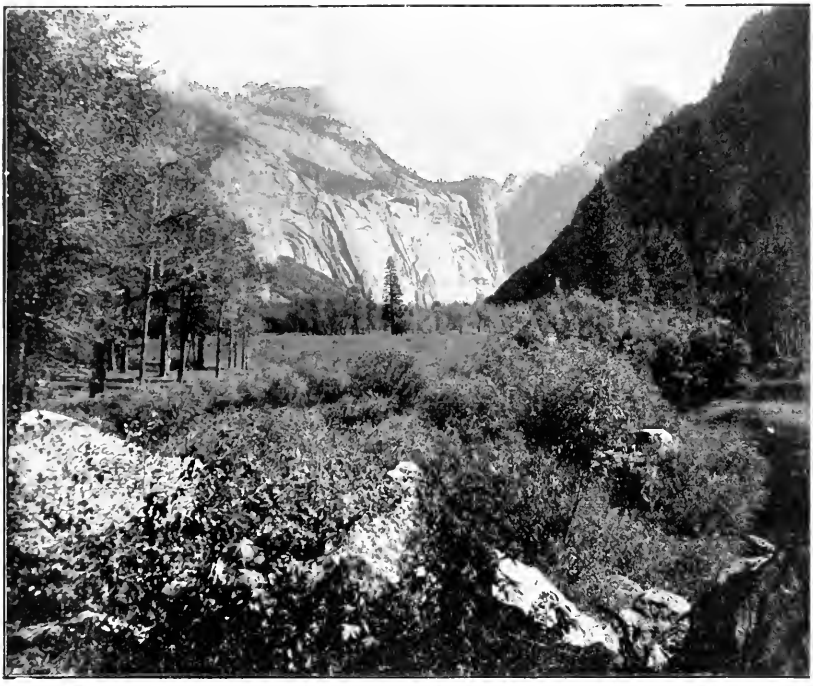
bay the valley is shut in between high mountains. Toward the southeast the valley narrows and the mountains become lower. In the middle and upper portion of the basin, there are broad reaches of open valley and low hills. On account of the semi-arid conditions prevailing in portions of the basin, the Salinas river, except during uncommonly wet seasons, is an insignificant one. During the summer its bed is dry in many places.

The mountain ranges which shut in the valley of the lower Salinas contrast quite strongly with each other. The Gavilan upon the east, tho attaining an elevation of three thousand feet, has only moderately steep slopes and presents the general appearance of much greater age than the Soledad hills upon the west. The latter rise also to about three thousand feet but present a steep and picturesque scarp toward the valley. The Salinas river flows close under this regular mountain wall, a fact which would indicate a recent dropping of the valley floor upon that side. Remarkably fine examples of debris fans are found along the steep slope of the mountains.

The Soledad hills form but the eastern ridge of a much higher and more important mountain block known as the Santa Lucia range. This range begins in the picturesque and rugged coast near Monterey and extends southeasterly along the ocean for about one hundred miles. It then passes inland, giving place upon the shore to another range. The Santa Lucia finally blends with the San Rafael and other mountains in eastern Santa Barbara county, and these in turn with the San Emedio mountains. The Santa Lucia is the most rugged and picturesque mountain range in the coast region of California. Its crest is from three thousand to five thousand feet high, and lying as it does only about five miles from the sea shore, the ocean slope of these mountains is exceedingly rugged and picturesque. In many places they rise with steep slopes from precipitous ocean cliffs. Upon the eastern slope of the range, the cañons which unite to form the Arroyo Seco are deep and narrow. The region is one of sharp ridges and cañons but scantily clothed with timber. The highest peak of the range is San Lucia, seven thousand feet high.

The San Luis range is that mountain block which replaces the Santa Lucia upon the coast toward the south. The seaward prolongation of this range forms a projecting headland known as Point Buchon. At the mouth of Morro bay, a few miles north of

this point, stands a great rock rising bare and precipitous from the ocean to a height of nearly six hundred feet. It is known as Morro rock and is by far the most striking single feature of the coast of California. It is formed of a very resisting igneous intrusion. This rock is but one of a series of similar peaks extending inland in a southeasterly direction thru the San Luis valley.



A SCENE IN THE YOSEMITE VALLEY.

Several of them rise from the open valley to a height of twelve hundred to fourteen hundred feet in rugged and picturesque forms. They result from differential erosion in rock masses of greatly varying hardness.

A remarkable and interesting valley lies to the southeast of the extreme head of the Estrella, a tributary of the Salinas. It is known as the Carriso plain, having a length of about fifty miles and a width of ten. A scarcely noticeable divide separates the plain from the basin of the Salinas. As it is, this great stretch of country shut in on most sides by low mountains has no outlet. The sink

at its centre is occupied by a salt marsh of considerable extent. The arid conditions prevailing here have kept the valley from being flooded and breaking the slight barrier between it and the Salinas. As will be seen later, the floor of this plain is continuous with an old peneplain occupying the upper Salinas valley. This is remarkable as being the only inclosed basin in the Coast Ranges.

The Cuyamas, or as it is known in its lower portion, the Santa Maria, is one of the most interesting rivers of the Coast Ranges. It rises far to the southeast in the San Emedio mountains and flowing northwesterly for many miles between the Mount Diablo, or rather the southern extension of that range, and the San Rafael mountains finally turns abruptly southwesterly, leaving the broad Cuyamas valley, and cañons directly across the Santa Lucia range to the ocean. The Cuyamas valley was probably formed as a consequence of fault movements which left it without an outlet. A lake resulted, and in the overflow of the lake originated the stream which cut the present cañon.

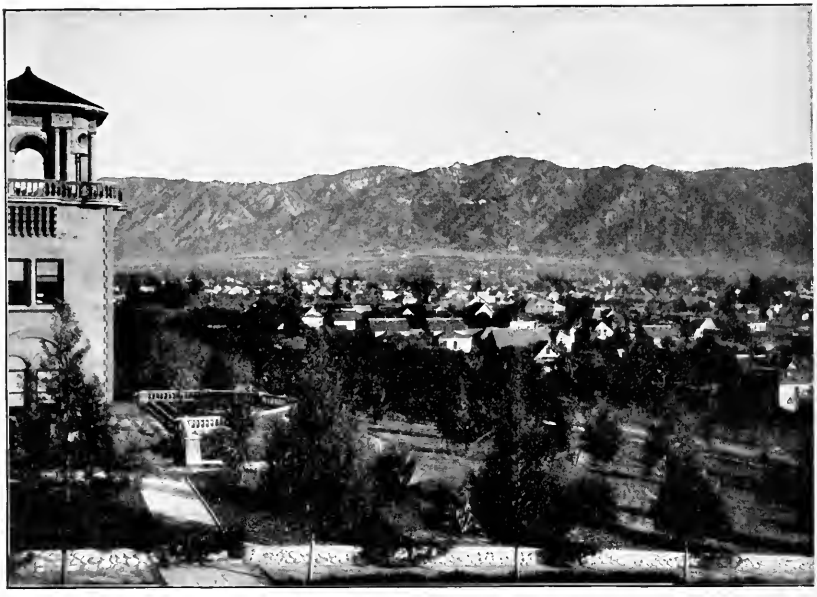
The extreme southeastern portion of the Coast Ranges form a rugged and complex group of mountains known as the San Rafael mountains. They are largely covered with dense brush, altho there is some timber where the conditions are favorable. The cañons are deep and show but little or no bottom land. From this region the Sisquoc and Santa Ynez rivers flow westerly, the Ojai and Sespe southerly. Zaca lake is a small but well known body of water in the western part of the range. It occupies the valley of a small stream which had graded its valley to correspond with the conditions existing when the coast was depressed about eight hundred feet.

The Santa Ynez is a regular and continuous range which borders the coast from Point Arguello easterly. Upon the north is the broad valley of the Santa Ynez river, while upon the south a narrow strip of land separates it from the ocean. This strip of land is, however, fertile and highly cultivated. The city of Santa Barbara is situated upon it.

From the foregoing description it may be judged that the larger valleys of the Coast Ranges have not developed contemporaneously with the cañons in the mountains which enclose them. The cañons correspond in their stage of development fairly well to those in the Klamath mountains and the Sierra Nevada, but the valleys have had a longer history. It is a complex history to be

sure, but structural conditions rather than erosion have determined in most cases the position and character of the valleys.

As illustrating how structural conditions have affected the topography, there might be mentioned a line of narrow valleys extending from the northern portion of the Sierra Madre mountains across the San Emedio, and northwest thru the Coast Ranges toward San Francisco. These valleys have been eroded as a result of earthquake movements in recent times. In fact the formation of fissures and low ridges resulted along this line from an earthquake not



PASADENA AND THE SIERRA MADRE.

more than forty years ago. The line of movement or fissure zone is in places half a mile wide, and many distinct ridges and depressions can be counted. Springs issue from this zone of broken rock and erosion is proportionately rapid.

As has already been stated the peneplain which was developed thru Tertiary time upon the slopes of the Sierra Nevada mountains, the Klamath mountains, and probably also in southern California, cannot be traced continuously thru the Coast Ranges owing to the strong deformation experienced in this region in late Tertiary time, as well as to the fact that during long intervals in the

Tertiary the central and southern portions of the Coast Ranges were submerged beneath the sea.

The fact that the main valleys of the Coast Ranges exhibit an apparently advanced phase of development, and that the main streams are generally subsequent, does not, then, indicate that this region has been elevated longer than the Sierra Nevadas.

The peneplain of the Klamath mountains can be traced continuously southward nearly to San Francisco bay, descending slowly from a height of three thousand to four thousand feet in the former region to about 1,500 feet near its southern limit. The planation was not complete for scattered peaks rise above this plain. During the development of the peneplain the most of the streams had adjusted themselves to the structural conditions. With the uplift they retained these courses so that we have now well adjusted streams where we might expect consequent ones.

With the close of the Pliocene, folding and faulting inaugurated new conditions thru much of the Coast Range area. In the northern portion the old plain was distorted but not broken. Many of the flat-topped crests of mountain ranges south of San Francisco bay probably date from the late Tertiary. One of the most important of these is to be observed upon the Santa Lucia range. In the middle portion of the range there is an area fully ten miles across, and many miles long, which, altho now deeply dissected, yet presents an almost level sky line at an elevation of about three thousand feet. There are many other areas of similar character scattered thru the central and southern Coast Ranges.

Following the post-Tertiary disturbances, and during the interval of the early Pleistocene submergence, when the coast was one thousand to fifteen hundred feet below the present level, conditions must have been favorable in places for the extension of the Tertiary peneplain, and for the evolving of partial plains of erosion upon the newly formed mountains as in the case of the Berkeley hills where there are strong indications of peneplanation at an elevation of about 1,500 feet.

As the coast began to rise from the Pleistocene submergence it remained long at a height above the present level of between 750 to 1,000 feet. Extensive plains corresponding to this height were formed in the valley of the Salinas, north of the Santa Ynez valley and in other places. In the Salinas valley, owing to the wide distribution of soft rocks, the erosion plain was particularly

extensive. It was fully 150 miles long reaching far southeast into the Carisa plains and across the crest of the Coast Ranges into the Great valley.

Since the elevation of the coast to its present height, broad valleys have been eroded in this plain and a new erosion plain is in process of formation. There are then to be recognized thru the central and southern Coast Ranges: (1) a broken and deformed plain of Tertiary age, remaining only as fragments here and there; (2) an extensive one of Pleistocene age but slightly deformed; and (3) a recent one being evolved out of the last. In the northern Coast Ranges, the Tertiary plain, tho deeply eroded and deformed, is continuous.

THE KLAMATH MOUNTAINS

The use of the term Klamath mountains has been limited to that portion of the Coast Ranges lying north of the south fork of the Trinity river and extending northwest to the ocean, and into Oregon. These mountains are limited upon the east by the line of contact between the older crystaline rocks and the lavas of the Cascade range. On the boundary between California and Oregon the Klamath mountains join the Cascade range in an unbroken ridge, but both north and south of this point broad valleys separate the two mountain ranges. In California the eastern border of the Klamath mountains extends south along the western edge of Shasta valley, then easterly around the southern base of Mount Shasta, and then bending south, follows down Pitt river to the Sacramento. Along much of this line the contrast in topography between the volcanic plains and the steep slopes of the Klamath mountains, is very marked.

Different portions of the Klamath mountains are known under different names. The Siskiyou range forms a group partly in California and partly in Oregon. The Scott and Salmon mountains lie to the south and include the highest peaks of the whole group, many rising from seven thousand to nearly ten thousand feet. The geological structure of the region is not as regular as in the Coast Ranges to the south, and as a consequence the mountains and valleys have no definite arrangement. The streams flow in deep, and generally narrow cañons, except in a few cases where basins inclosing softer beds than those forming the main body of the mountains have given rise to valleys of considerable size. Among these are Scott's valley, Hay Fork valley, and the valley about Weaverville.

Among the larger streams are the Klamath, Trinity, and Sacramento rivers. The Klamath river rises in the Klamath lake basin east of the Cascade range in Oregon. It flows southwesterly into California, and, after crossing the depressed portion of the Cascade range, pursues a tortuous course in a deep cañon across the Klamath mountains to the ocean. The mountains traversed rise to a height of six thousand or seven thousand feet, and the question naturally arises why the river should have cut across these mountains rather than have turned southerly thru Shasta valley where a low divide of only 3,400 feet elevation above the sea separates it from the basin of the Sacramento river. In this case the most reasonable explanation seems to be that of a gradual rise of

AVALON, SANTA CATALINA ISLAND.—A harbor made by the partial flooding of a valley of erosion. Result of last subsidence of the coast.

the Klamath mountian region after the river had acquired its present course.

The source of the Sacramento river is in large springs issuing from the lava at the southwest base of Mount Shasta. The stream flows southerly and, after leaving the lava, crosses a spur of the Klamath mountains before reaching the Sacramento valley. Its course for many miles is thru a picturesque cañon The cañon

antedates the latest of the lava streams from Shasta, for one of them flowed down thru it for fifty miles. The river has cut thru the lava in most places and is now deepening its channel again. Among the picturesque features of the upper Sacramento cañon are the Castle Crags, bare and castle-like pinnacles of granite.

The Trinity river drains the southern portion of the Klamath mountains. The basin of this river is separated from the Sacramento valley by Bully Choop mountains, while upon the north are the Salmon and Scott mountains.

The higer portions of the Klamath mountains, particularly the Salmon range, were glaciated during the Glacial period. The glaciers were more local than those in the Sierra Nevada mountains and did not descend below five thousand feet. The higher mountain valleys contain numerous little lakes, which with the moraines and polished rock surfaces are characteristic of glaciated areas.

Viewing the Klamath mountains as a whole, we find that they have many physiographic characters in common with the Sierra Nevada mountains. There is the same absence of isolated peaks rising much above the elevated ridges, and the same deep cañons carved out by erosion. Geologically they also have much in common.

THE SIERRA MADRE AND PENINSULA RANGES

Under this head will be included all that part of California lying south of the San Emedio mountains and west of the Great Basin area. The broad and high range of mountains extending south of east from the San Emedio region, forms the watershed between the fertile valleys of southern California and the Mojave desert. This mountain block is known at various points under different names. The designation Francisquita mountains is given to that portion lying south of Antelope valley (western arm of the Mojave desert) and west of Soledad pass. East of this pass the range broadens and becomes much higher, reaching an elevation of nine thousand feet in San Antonio peak. This portion is known as the San Gabriel range.

At Cajon pass the range is again depressed sufficiently to permit of its being crossed by a railroad. Beyond the pass to the east rises the still more lofty and rugged San Bernardino range culminating in Grayback, over eleven thousand feet high. To the

east the range now becomes lower and forms the low divide between the Mojave and Colorado deserts.

The Sierra Madre range, as a whole, was elevated near the close of the Tertiary period, probably thru the combined influence of folding and faulting. The southern front of the range is particularly bold and imposing rising as it does from extensive valleys and waste slopes elevated less than one thousand feet above the sea. The mountains are deeply cut by sharp V-shaped cañons in which are insignificant streams during the dry season. After heavy storms each carries a muddy torrent, which, spreading out at the mouth of its cañon, contributes its load to the building up of the waste slope.

But one stream of any consequence, the Mojave river, drains the northern side of the San Bernardino range, and it is soon lost in the sands of the desert. Upon the southern side the San Gabriel and Santa Ana rivers are the most important, but even these carry but little surface water to the ocean. The most of it is used in irrigation.

The Santa Clara river drains the northern portion of the area under discussion. Its tributaries head in the San Emedio, Francisquita, and San Gabriel mountains. In the middle and upper portions of this basin the rainfall is light, and except after periods of heavy rain but little water flows upon the surface of the river bed. The valley of the Santa Clara expands to a width of twelve or more miles near the ocean, and for fifty miles back from the coast is highly cultivated. Mounts Pinos, Alamo, and Frazier upon the northern edge of this basin are the loftiest peaks of the San Emedio range. The two latter peaks in particular have nearly flat summits of considerable extent which appear to be remnants of an ancient peneplain. The Tertiary and Pleistocene deposits high up on the flanks of these mountains testify to very marked elevation in recent geological times.

The valley of the Santa Clara river seems to have originated in a structural depression formed thru faulting. The San Fernando range bordering this valley upon the south and eighteen hundred to three thousand feet high gives evidence in its bold scarp facing the valley, and gentle slope to the south, of being a raised and tilted block. The valley of the Santa Clara river has like most of the other large streams had its bed graded up in adjustment to the present conditions.

Extending east and west along the north side of Santa Monica bay, and reaching eastward to Los Angeles, is another mountain ridge known as the Santa Monica range. Its highest peaks reach an elevation of nearly three thousand feet. The range is formed largely of volcanic rocks. Structurally it appears to be continuous with the islands to the west lying off Santa Barbara channel.

An irregular line of low mountains stretches along near the southern base of the San Gabriel range and is separated from it by a waste filled valley. In the eastern end of the San Fernando valley this elevation is known as the Verdugo mountains. Farther east are the San Rafael hills. Between Los Angeles and Pasadena these hills are much eroded, but beyond the San Gabriel river they

MILL VALLEY AND MT. TAMALPAIS.

rise again to form the Puente hills. Tracing them farther still, they are found to increase in height, forming the steep and high Santa Ana range whose eastern front is a great fault scarp of recent geological origin. The highest peak of the range has an elevation of 5,600 feet.

Between the San Gabriel river and San Fernando the streams issuing from the San Gabriel range have cut across this line of hills and mountains, and in many places have nearly obliterated them. The waste slopes sweep across them in even grade.

The plain stretching from Los Angeles south and west to the

coast formed the floor of a broad bay during the last extensive submergence of this region. It has been but slightly modified by erosion.

The Santa Ana is the largest stream of southern California. Rising in the San Bernardino range it flows westward past San Bernardino and Riverside thru a region of low relief, and then cañons thru the northern end of the Santa Ana range. It emerges from the cañon upon a broad flood plain which extends to the ocean. The river was probably either superimposed upon the Santa Ana range because of an original deposit of soft sediments filling the basin thru its middle course, or it cut the cañon as the range was slowly elevated across its course.

The old topography in the region about Riverside is most interesting. The graded condition of the streams, the low hills of granite and ancient crystalline schists afford us a picture of what nearly the whole of southern California might have been if it were not for the faulting which gave rise to the rugged ranges of the region. If it were not for these high mountains arid conditions would prevail and there would be another Mojave desert.

This area of ancient topographic forms stretches south from Riverside for many miles and also west to the Puente hills. It presents the most striking contrast to the bold scarps of the Santa Ana, San Bernardino, and San Jacinto ranges.

South of the San Bernardino range, and on the south side of the low pass leading east to the Colorado desert, rises the rugged peak of San Jacinto to a height of about eleven thousand feet, twin brother to Mount San Bernardino.

Mount San Jacinto may be termed the northern end of the Peninsula range, that continuous chain of mountains stretching from this point south for nearly one thousand miles thru the peninsula of lower California. This range rises as a general thing very abrubtly from the desert and gulf at its eastern base, and in position and structure might be considered a worthy continuation of the Sierra Nevada mountains. The lower portion of the scarp of the range near the Mexican line is particularly bold. Here recent faulting has raised the mountains about one thousand feet. Upon the slope of Carrizo mountain mollusc borings still remain upon the surface of the limestone at an elevation of twelve hundred feet.

The western portion of Mount San Jacinto, overlooking the

broad reaches of the valley of the same name, is a bold fault scarp. San Jacinto river flowing for some distance at the base of this scarp turns abruptly southwest, and crossing the region of old topography already described, empties in seasons of exceptionally wet weather into Lake Elsinore, the largest lake of southern California. This lake lies at the eastern base of the southern continuation of the Santa Ana fault scarp, and occasionally overflows northwesterly down the Temescal valley to the Santa Ana river.

Following the fault scarp from Elsinore for thirty miles in a southeasterly direction we come to Temecula creek, a stream of considerable size rising to the south of San Jacinto. This stream instead of flowing northwest along the base of the scarp as we should naturally expect it to do, has instead cut a cañon directly across the scarp and pursues a fairly direct course to the ocean. Here as in many other cases there are two hypotheses to choose from to account for the course of the stream. Either the mountain scarp has been slowly raised across its course or the valley in the depressed block to the east of the fault was filled with pleistocene deposits to a level with the rim of the scarp at the time the drainage was established. Which explanation is the correct one has not yet been determined.

The cañon which the stream has cut is narrow and quite picturesque. Standing at the top of the present steep walled cañon we appear to be in the centre of a broad valley of older topographic forms, a valley eroded and fairly matured before the last uplift.

South of Temecula the fault scarp disappears altho Smiths mountain which appears to be an uplifted block may be related to the same line of disturbance. Toward the southern boundary of the state the Peninsula range becomes more simple. Back of San Diego the crest of the range is nearly as far from the fault line at its eastern base as from the western. The features of an ancient baselevel are particularly noticeable upon the crests of the mountains and ridges. The summit of Smiths mountain as well as that of the Laguna mountains are fine examples of flat topped. Viewed from a point east of Fallbrook the western slope of the mountains forms a nearly even sky line gently dipping towards the coast. The present cañons have been eroded in this ancient plain, and in many cases they have widened to extensive valleys. The main streams are completely graded, flowing over a sand floor. Their beds are dry during a great part of the year but water can be obtained in abundance by sinking thru the sand.

The extensive mesa extending from San Diego to ocean side is an old sea floor. Except for the steep walled cañons cut across it the surface has been but slightly modified since the uplift. One can trace in places the successive lines of sand dunes formed as the coast rose. San Diego bay has probably been formed thru the drowning of a river valley in connection with the action of ocean waves and currents.

COAST FEATURES

The fact has already been mentioned that along the whole length of the California coast the topography resulting from subaerial erosion has been modified by wave action and sedimentation incident to depressions of the coastal area. The lower portions of the stream valleys once excavated deeper than they now appear were partly filled with sediments when the ocean level was 1000 to 1500 feet higher. At the next period of elevation stream erosion was again active. Now the valleys are again being silted up to sea level as a consequence of submergence.

Nearly every stream along the whole length of the coast has either a tidal lagoon at its mouth, the tide entering from a few hundred yards to a number of miles, or an extensive alluvial plain. Those streams like the Klamath river, containing a large volume of water the year around, maintain an open channel to the sea, the tide flowing in and out. The entrance to San Francisco bay is preserved not so much thru the volume of the river which finds its outlet here as thru the vast amount of tidal water pouring thru the Golden Gate.

Those streams like the Salinas which flow a considerable amount of water for only a portion of the year, and whose channels are deeply filled with detrital material do not show the effects of subsidence as distinctly because of the filling in of their estuaries. Along the southern coast there are many streams of this character. There are other small streams flowing only during wet weather and which carry but a small amount of the detrital material. During the summer the waves and ocean currents block the outlets of these and the enclosed lagoons on drying leave a surface whitened with more or less salt. These conditions are beautifully shown along the coast of San Diego county where the cañons of many small streams have been flooded by subsidence.

Numerous wave-cut terraces of varying width are to be

observed at favorable points along the whole coast of California. These range from ten feet to fifteen hundred feet in elevation.

The great mesa north of San Diego is a wave cut plain. Its upper limit has an elevation of about eight hundred feet.

San Pedro hill, forming a prominent feature of the coast opposite Los Angeles, is finely terraced up to an elevation of twelve hundred feet. San Clemente island, which, like the other islands, seems to have moved in the main with the mainland, is terraced up to nearly fifteen hundred feet.

At Point Sal, in northwestern Santa Barbara county, there is a broad terrace at one thousand feet. Upon the seaward slopes of San Luis range there are many terraces, some of them remarkably perfect, they range in height from ten to 750 feet. Upon the slopes of the Santa Lucia range they appear at heights of 750 to one thousand feet. Very fine terraces also appear along the slopes of the Santa Cruz range. North of the mouth of Russian river they are recognizable as high as fifteen hundred feet. The upper one forms a bench against the old peneplain so distinctly shown in that region.

As the land rose permitting the formation of these terraces, there was a prolonged stop at an elevation varying from 750 to one thousand feet; the difference between these figures possibly indicating the amount of differential movement since. The breadth of this terrace and its correspondence in height to the broad peneplain of Pleistocene age which is very prominent thru portions of the Coast Ranges marks this as an important stage.

As the coast rose the rivers also formed terraces. Below Bradley upon the Salinas river six terraces can be seen.

Along nearly the whole length of the state except where the mountains rise directly from the ocean cliffs there is a coastal plain. This varies in width from a fourth of a mile to several miles, and in height from sixty to two hundred feet. Along portions of the Mendocino coast where this plain is broad and furnishes a large part of the best land in the county, much of it attains a height of four hundred feet.

The coast of California is bordered by a submarine plateau sharply marked off from the deep waters of the open Pacific. This plateau is a part of the continental mass and has at various times in its history been wholly or in part raised above the water. The present islands rise from the surface of this plateau, and rep-

resent peaks of mountain ranges structurally related to those upon the adjoining mainland.

The submarine plateau is quite narrow along the coast of northern California. From point Arena southward it slowly widens sweeping just outside of the Farrallon islands, twenty miles off the Golden Gate. The surface of the plateau generally slopes very gradually out to the one hundred fathom curve when it takes on a much steeper descent to the deeper portions of the plateau or to the abyssal depths of the Pacific.

The plateau narrows opposite Monterey bay, and along the high Santa Lucia range the one hundred fathom curve is only 4.6 miles from shore. Farther south it widens, sweeping out side of the channel islands, and finally attaining a width of 150 miles. The surface of the broad portion of the plateau is far from being uniform. Some of the islands rise over two thousand feet above the sea level, and in places the depth of the water at their bases is two thousand to three thousand feet. An elevation of less than one thousand feet would connect the Channel islands (those lying off Santa Barbara) with the mainland. Such an elevation existed during the early Pleistocene, for remains of the mastodon and other mammals are found upon one of them. The water about San Clemente and Santa Catalina is much deeper.

Crossing this marginal plateau at various points are submarine valleys which from their position and general character are believed to have been formed by subaerial erosion. Many of the most prominent valleys lie opposite the mouths of the present land valleys, some are not thus situated. The greatest of the submarine valleys is that occupying the bay of Monterey. It extends westerly from a point near the mouth of the Pajaro and Salinas rivers and down across the plateau to the abyssal depths of the Pacific. It reaches so close to the shore as to have influenced the location of a wharf. It has been thought that because of the absence of any submarine valley opposite the Golden Gate the drainage of the Great valley once entered the ocean thru the valley in Monterey bay.

Many important and interesting facts connected with the physiographic history of California yet remain to be studied. Enough has been said however to give some conception of the varied features of the state, and to show the richness of the geographic material at hand for our schools.